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**Surface Radiological Investigations  
at HFIR/TRU  
Waste Collection Basins  
7905, 7906, 7907, 7908,  
and Environs**

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**Surface Radiological Investigations at HFIR/TRU Waste Collection  
Basins 7905, 7906, 7907, 7908, and Environs**

M. S. Uziel  
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## ABSTRACT

A surface radiological investigation was conducted at the High Flux Isotope Reactor/Transuranium Processing Plant (HFIR/TRU) Waste Collection Basins 7905, 7906, 7907, 7908, and environs from May to July of 1989 and February to March of 1990. The purposes of this survey were (1) to determine the presence, nature, and extent of surface radiological contamination and (2) to recommend interim corrective measures to limit human exposures to radioactivity and minimize the potential for contaminant dispersion.

Surface gamma exposure rates over the site generally ranged from 24 to 48  $\mu\text{R/h}$ . Inside the HFIR complex fence, most elevated gamma levels were attributed to radiation emanating from Basins 7905 and 7906, with 1-m measurements reaching 180  $\mu\text{R/h}$  near the Contamination Area fence. Nine small spots of surface contamination ranging from 60 to 960  $\mu\text{R/h}$  were identified inside the HFIR complex fence, and a cluster of six small spots ranging from 48 to 320  $\mu\text{R/h}$  were found immediately south of the fence line.

South of the HFIR complex fence, a region on either side of the discharge stream from Outfall 381 showed surface gamma exposure rates ranging from 3000 to 45,000  $\mu\text{R/h}$ . Gamma levels along the edge of the discharge stream from Outfalls 382 and 383 ranged from 48 to 220  $\mu\text{R/h}$ , the edge of Outfall 281 discharge stream ranged from 24 to 2300  $\mu\text{R/h}$ , and the edge of Melton Branch streambed ranged from 48 to 460  $\mu\text{R/h}$ . The floodplain generally measured 47 to 1700  $\mu\text{R/h}$ . Soil, water, and vegetation samples from the study site contained  $^{60}\text{Co}$ .

Recommendations for corrective actions are included.

## 1. INTRODUCTION

A surface radiological investigation was conducted at the High Flux Isotope Reactor/Transuranium Processing Plant (HFIR/TRU) Waste Collection Basins 7905, 7906, 7907, 7908, and environs from May to July of 1989 and February to March of 1990. This survey was performed by the Measurement Applications and Development Group of the Health and Safety Research Division (HASRD) of the Oak Ridge National Laboratory (ORNL) at the request of Environmental Restoration Program (ERP) personnel at ORNL. The purposes of this survey were (1) to determine the presence, nature, and extent of surface radiological contamination and (2) to recommend interim corrective measures to limit human exposures to radioactivity and minimize the potential for contaminant dispersion.

The HFIR/TRU Waste Collection Basins 7905, 7906, 7907, and 7908 have been assigned to Waste Area Group (WAG) 8 and to Solid Waste Management Units (SWMUs) 8.1a, 8.1b, 8.1c, and 8.1d, respectively, by the ORNL ERP staff.<sup>1</sup> Areas south of the basins near Melton Branch are part of WAG 2, SWMU 2.2.<sup>1</sup> The basins are shown at the far right of Fig. 1.1.

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Fig. 1.1. Aerial view showing the HFIR/TRU waste collection basins at the far right of the photograph. Melton Valley process waste storage tanks are located to the left of the basins and the HFIR cooling tower is above the basins.

## 2. SITE HISTORY

Basins 7905, 7906, 7907, and 7908 are located south of HFIR (Fig. 2.1) in Melton Valley at ORNL grid coordinates (measured in feet) N16,740/E32,620; N16,700/E32,490; N16,680/E32,380; and N16,660/E32,310, respectively.<sup>1</sup> The basins were commissioned in 1965<sup>1</sup> and continued to operate until May 25, 1989, when waste streams were diverted to the Melton Valley process waste storage tanks.<sup>2</sup> In an emergency, Basin 7905 can still be used as a temporary holding pond for blowdown water from the HFIR cooling tower (Building 7902).<sup>2</sup>

Basin 7905 was formerly an intermediate storage and collection basin for the HFIR facility. The basin also provided emergency storage for blowdown water from the HFIR cooling tower when repairs were necessary. The blowdown water was radioactively contaminated if a leak had occurred in the system. Water entering the basin came from floor drains, laboratory drains, steam condensates, process vessel cooling water, and precipitation falling directly on the basin. The major contaminating isotope was <sup>60</sup>Co. Nonradioactive wastes included nitric acid, sodium hydroxide, and sulfuric acid. Basin 7905 is frequently referred to as the HFIR Cold Pond.<sup>3</sup>

During the time of operation, Basin 7906 received waste primarily from HFIR, but could also receive diverted waste streams from the Radiochemical Engineering Development Center [REDC, which includes Building 7920 (formerly TRU) and Building 7930 (formerly Thorium-Uranium Recycle Facility, TURF)].<sup>3</sup> The major radionuclide from HFIR was <sup>60</sup>Co; principal contaminants from TRU and TURF facilities were plutonium and daughter nuclides. Nonradioactive wastes included sodium and potassium hydroxides and acids.<sup>3</sup> Basin 7906 is sometimes referred to as the Hot Pond.<sup>1</sup>

Basins 7907 and 7908 received process waste streams from REDC. During operation, Basin 7907 was filled and emptied alternately with Basin 7908. Waste streams were derived from floor drains, laboratory drains, steam condensates, and process vessel cooling waters. The major constituent in the process waste was <sup>244</sup>Cm. Basin 7907 is also known as the No. 3 or TRU A Pond, and Basin 7908 is known as TRU B Pond.<sup>3</sup>

While in operation, all four basins were monitored for radionuclide content prior to discharge into Melton Branch. If analysis indicated contamination, the effluent was pumped to the Equalization Basin (3524) in Bethel Valley<sup>4</sup> and treated at the Process Waste Treatment Plant (3544) before discharge to White Oak Creek through a National Pollutant Discharge Elimination System (NPDES) discharge point.<sup>1</sup>

Basin 7905 stores up to 900,000 L (240,000 gal) and measures 26 × 35 m (86 × 116 ft) at the top of the berm and 12 × 21 m (40 × 70 ft) at the bottom of the pond. Elevation at the top of the basin berm is 245 m (804 ft) above mean sea level. Maximum liquid depth is 2.1 m (7 ft); sediment depth is 29 cm (12 in.).<sup>3</sup>

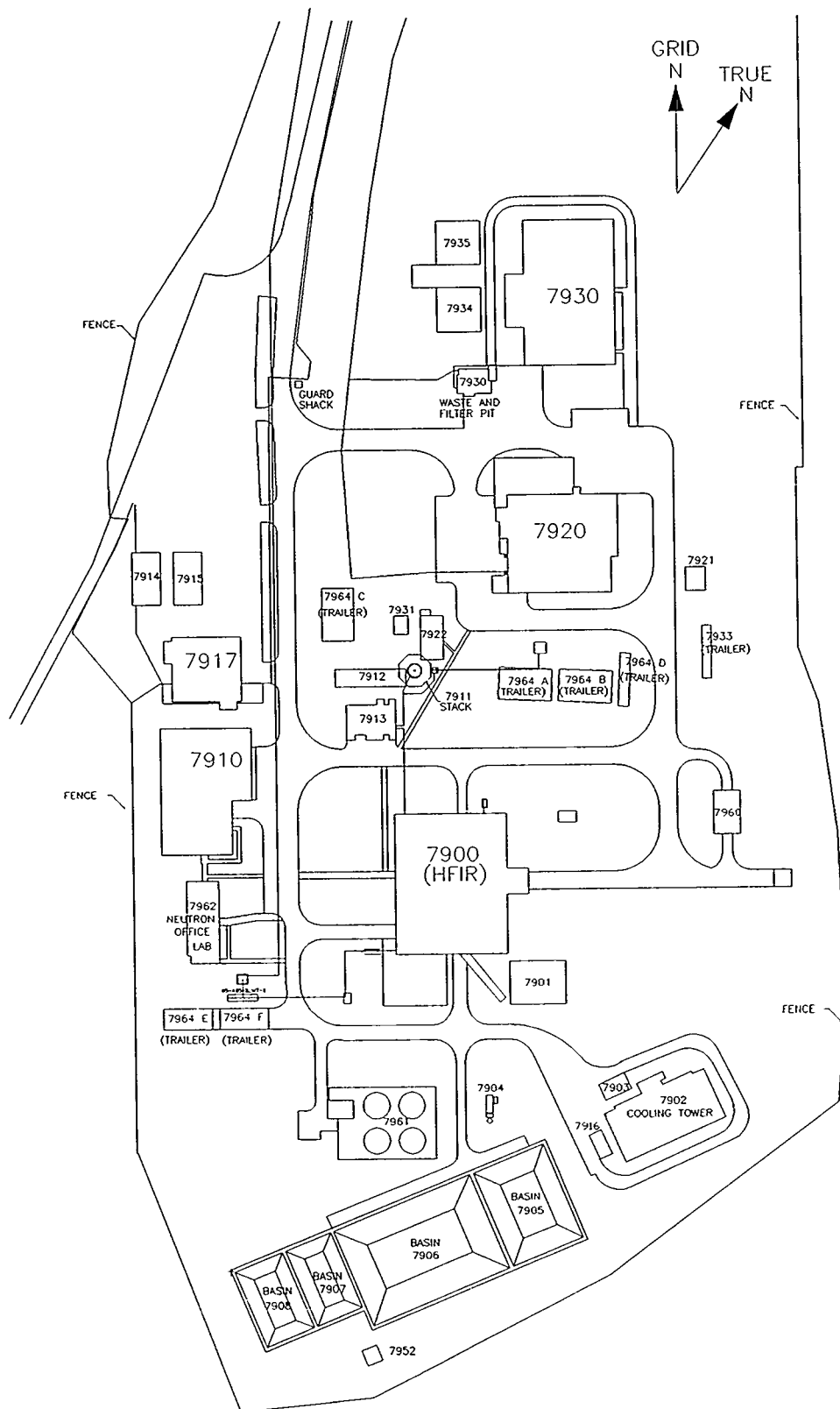


Fig. 2.1. Diagram of the High Flux Isotope Reactor (HFIR) complex.

Basin 7906 (Fig. 2.2) has a storage capacity of 1.9 million L (500,000 gal). The basin measures 51 x 35 m (167 x 116 ft) at the top and 37 x 21 m (121 x 70 ft) at the bottom.<sup>1</sup> Elevation at the top of the basin berm is 245 m (804 ft) above mean sea level.<sup>4</sup> The reported sediment depth is about 20 cm (8 in.).<sup>5</sup>

Basins 7907 (Fig. 2.3) and 7908 are identical. Each basin has a capacity of 180,000 L (50,000 gal) and measures 18 x 24 m (60 x 80 ft) at the top of the berm. Depth is approximately 3.4 m (11 ft). Average sediment depth is about 6 cm (2.4 in.).<sup>1</sup> All four of the ponds are open, unlined, and earth-bermed with gravel riprap along the basin walls.<sup>4</sup>

Sludge and influent water samples, collected from the HFIR/TRU waste collection basins during January and February 1986, were analyzed for metal, pesticide, herbicide, and volatile organic constituents. None of the data exceeded the appropriate EPA Extraction Procedure (EP) Toxicity Test limitations in either the metal or pesticide/herbicide categories, and only a few of the organic constituents were present at levels above the analytical detection limits. The ignitability, reactivity, and corrosivity tests on sludge all proved negative. All flash points were  $>70^{\circ}\text{C}$ , pHs were between 7.0 and 9.0, and none of the reactivity characteristics were exhibited.<sup>6</sup>

Four quarters of groundwater monitoring in 1986 indicated significantly higher levels of nitrate, sulfate, sodium, and gross beta activity in a downgradient well as compared to wells upgradient of the 7900 area. Migration of these contaminants appeared to be in an easterly direction toward the downgradient well.<sup>7</sup>

Concentrations of radionuclides in sediment samples from the 7905, 7906, 7907, and 7908 impoundments are shown in Table 2.1. High concentrations of a neutron activation product ( $^{60}\text{Co}$ ) at 7905 and 7906 are not surprising since these impoundments received wastewater from HFIR. On the other hand, Pu concentrations at 7908 are quite low considering that this impoundment received process waste from the REDC facility. In 1987, the estimated total inventory of the 7905, 7906, 7907, and 7908 impoundments was  $<0.3$ ,  $<1$ ,  $<0.004$ , and  $<0.008$  Ci, respectively.<sup>8</sup>

Three outfalls located south of the HFIR complex are currently listed as Category III discharges (unpermitted process and/or laboratory wastewater). Outfall 381 is a storm drain that formerly received effluent from Basin 7906. The pipe from the impoundment has been disconnected and plugged as part of the Nonradiological Wastewater Treatment Plant (NRWTP) project. Outfall 382 is a storm drain that formerly conveyed discharge from a temporary NPDES outfall, the Melton Valley collection tanks, to Melton Branch as part of the NRWTP. The discharge line from the tanks has been removed and the connection has been plugged. Outfall 383 is a storm drain that serves the southwest side of the HFIR complex. No process or laboratory drainage has been found to contribute to this outfall, and additional monitoring has detected no pollutants in 383 effluent at levels of concern. Outfalls 381, 382, and 383 have been proposed for recategorization as Category I outfalls (storm drains). Outfall 281, located south of the HFIR complex, is currently listed as a Category II outfall (parking lot, roof, storage area, spill area, cooling water, or condensate drains).<sup>9</sup>

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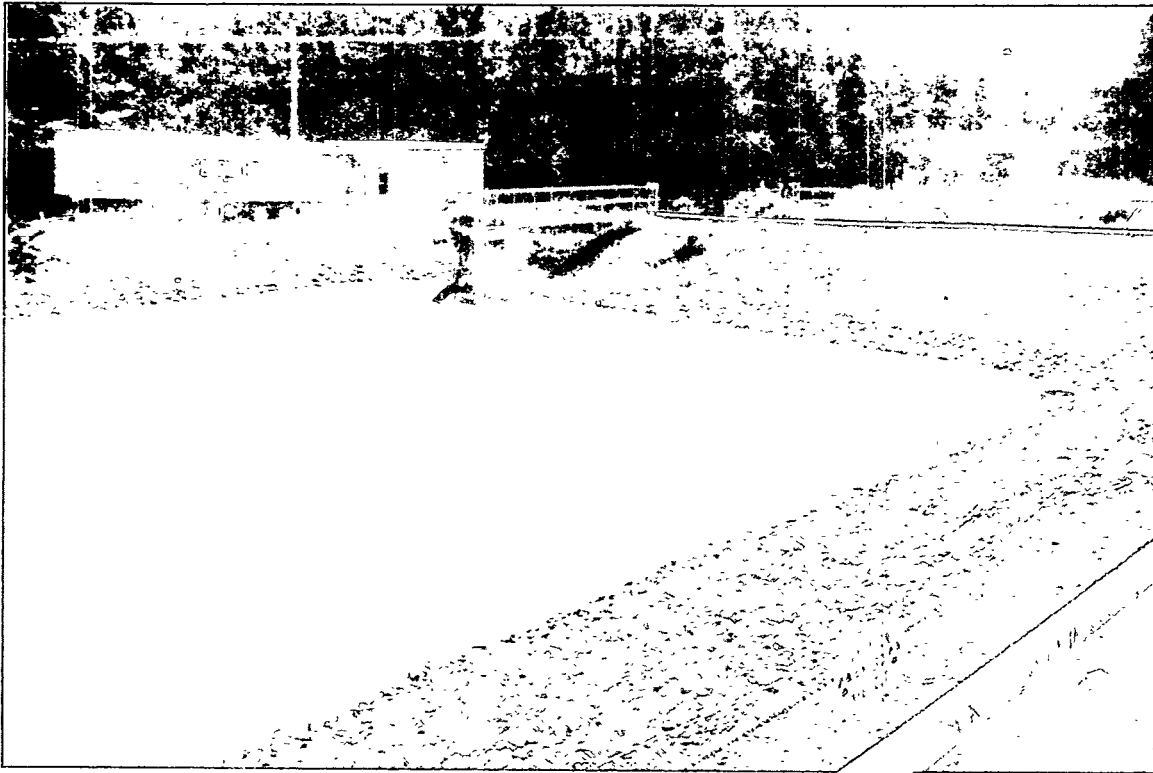


Fig. 2.2. View looking south at Basin 7906.

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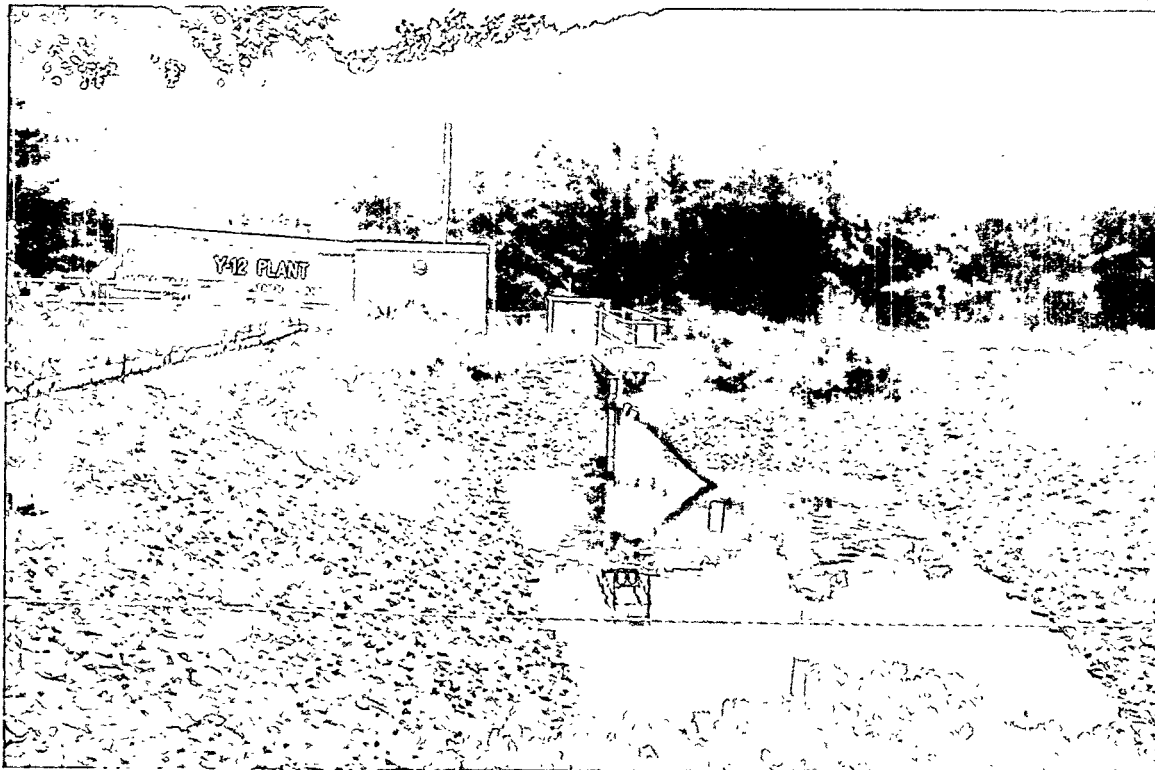


Fig. 2.3. View looking south at Basin 7907.

Table 2.1. Concentrations of radionuclides in sediment samples from the 7905, 7906, 7907, and 7908 impoundments

Radionuclide	Concentration (pCi/g) dry wt			
	7905 <sup>a</sup>	7906 <sup>a</sup>	7907 <sup>b</sup>	7908 <sup>b</sup>
Gross alpha	400	190	170	780
Gross beta	7,800	14,000	84	210
<sup>137</sup> Cs	120	240	27	94
<sup>238</sup> Pu	c	c	c	26
<sup>239</sup> Pu	c	c	c	54
<sup>241</sup> Am	<270	<270	<270	<270
<sup>60</sup> Co	14,000	24,000	30	9
<sup>90</sup> Sr	32	94	5	9

<sup>a</sup>Composite of eight samples.

<sup>b</sup>Composite of seven samples.

<sup>c</sup>Not measured.

Source: C. W. Francis and O. M. Sealand, *Concentrations of Radionuclides in ORNL Wastepond Sediments and Their Leaching Characteristics*, Oak Ridge National Laboratory, ORNL/RAP/LTR/87-70 (September 1987).

### 3. SURVEY METHODS

A comprehensive description of the methods and instrumentation used in this survey is presented in *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program*, Oak Ridge National Laboratory, ORNL/TM-8600 (April 1987).<sup>10</sup> All direct measurement results presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations measured in environmental samples.

#### 3.1 GAMMA RADIATION

Gamma radiation was measured with a sodium iodide (NaI) scintillation probe connected to a Victoreen Model 490 Thyac III ratemeter. Because NaI gamma scintillators are energy dependent, measurements of gamma radiation levels made with these instruments must be normalized to pressurized ionization chamber (PIC) measurements to estimate gamma exposure rates. The function used for these conversions is:

$$y = x \times CF$$

where

$y$  = the exposure rate in  $\mu\text{R/h}$ ,

$x$  = the scintillometer measurements in thousand counts per minute (kcpm).

CF = the slope of the regression line calculated by plotting a selected number of PIC measurements ( $\mu\text{R/h}$ ) vs scintillometer measurements (kcpm) at the same locations.

Because of the widespread distribution of measurements found at the HFIR/TRU waste collection basins, four conversion factors were derived.

Inside the HFIR complex fence, CF = 1.2.

South of the HFIR complex fence, for

$x$ = 10 to 40 kcpm,	CF = 1.2 ;
$x$ = 41 to 100 kcpm,	CF = 2.2 ;
$x$ = 110 to 650 kcpm,	CF = 2.9 .

When gamma radiation levels exceeded the limits of the NaI gamma scintillator (800,000 cpm), measurements made with a closed Geiger-Mueller survey meter (GMSM), Model Q-5218, equipped with a side-window probe (30-mg/cm<sup>2</sup> wall thickness), were converted to exposure rates by using the following instrument-specific conversion factor based on <sup>226</sup>Ra:

$$3100 \text{ cpm} = 1 \text{ mR/h} \quad \text{or} \quad 3.1 \text{ cpm} = 1 \text{ } \mu\text{R/h} .$$

At one contaminated area, radiation was also measured with a paper-shell cutie pie ionization chamber (standard model), which gives more accurate readings in high-radiation areas. Differences between measurements made with the GMSM and those made with the cutie pie can be attributed to differences in distance from the source (ground surface) to the center of the measurement chamber. With the GMSM, the source is ~1.3 cm from the center of the chamber; with the cutie pie, the source is ~5 cm from the center of the chamber. The larger distance gives the lower radiation measurement.

### 3.2 SCOPE OF THE SURVEY

The survey included:

- Measurement of gamma exposure rates at 1 m above the ground surface and at the surface at 39 selected points.
- A surface gamma scan of the area surrounding the HFIR/TRU Basins 7905, 7906, 7907, and 7908 and land areas south of the basins to Melton Branch (see shaded area in Fig. 3.1). Regions inside the fenced Contamination Area control zone, inside the wall surrounding the Melton Valley process waste storage tanks, and inside on-site buildings were excluded from the survey. A NaI scintillation probe held approximately 5 cm (2 in.) above the ground surface was used to detect gamma radiation. When radiation levels exceeded the detection limits of the scintillator, the GMSM and, in one case, the cutie pie ionization chamber were used.
- Radionuclide analysis of 15 soil samples collected from nine locations.
- Radionuclide analysis of three water samples.
- Radionuclide analysis of one vegetation sample.

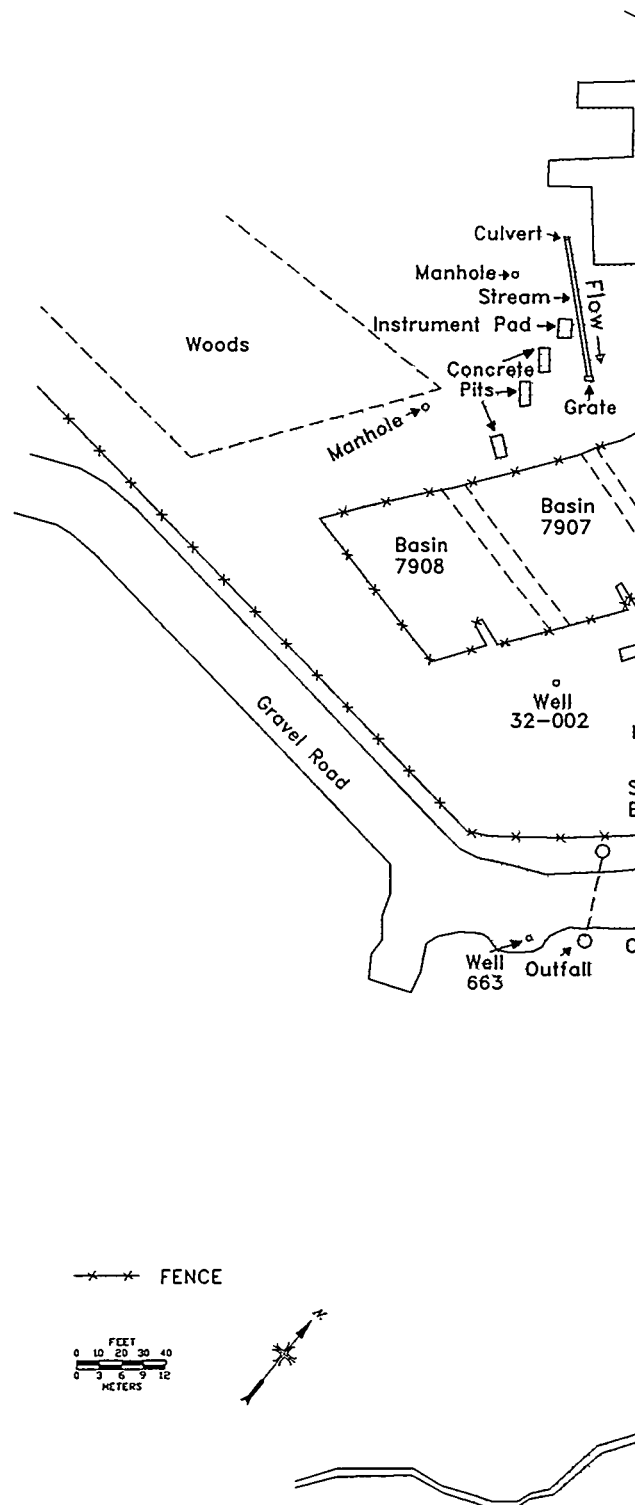
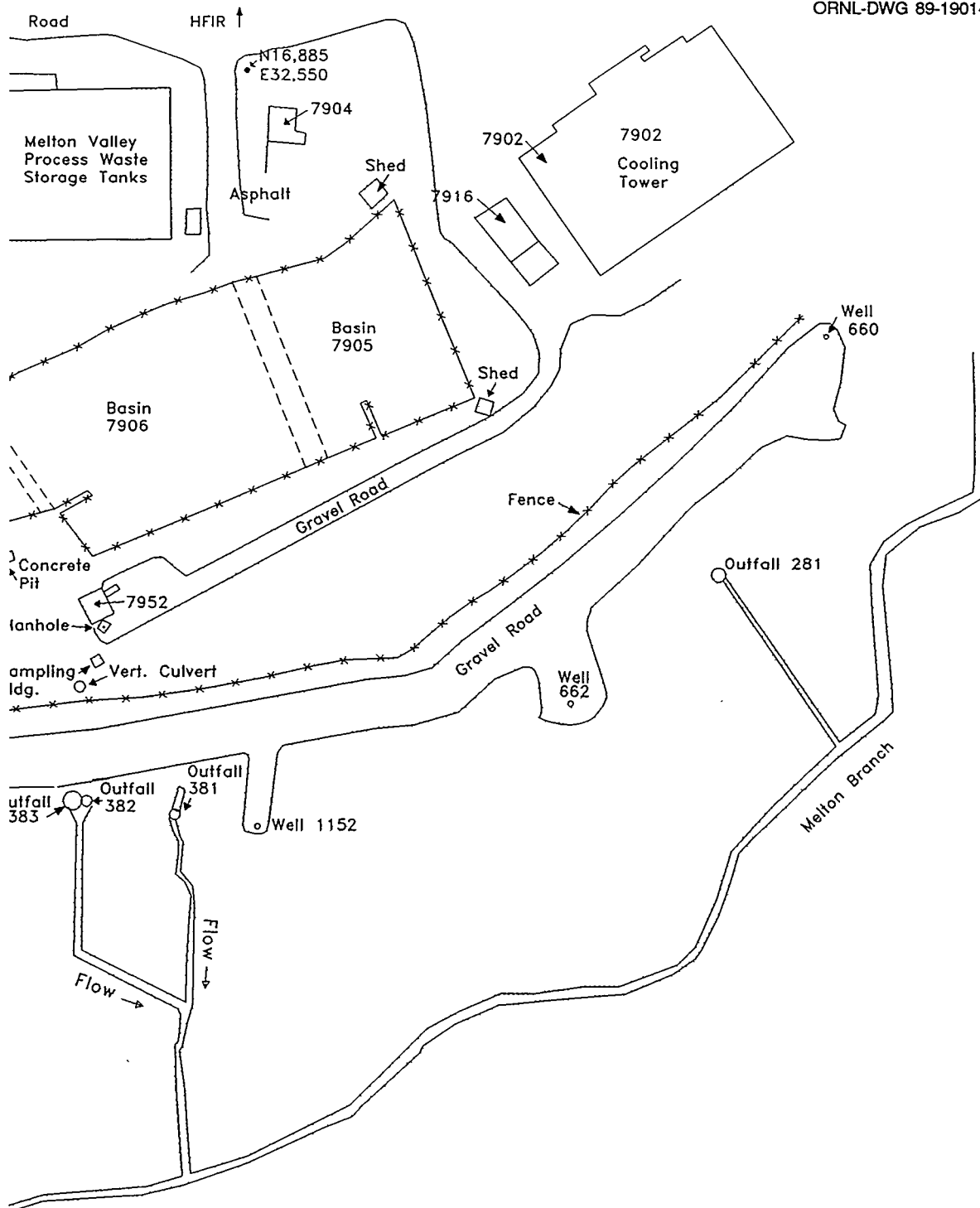


Fig. 3.1 Diagram of the HFIR/TRU waste



te collection basins. Shading indicates the area covered by the surface gamma scan.

## 4. SURVEY RESULTS

### 4.1 GAMMA EXPOSURE RATES AT SELECTED POINTS

Results of gamma exposure rate measurements at 39 selected points are shown in Fig. 4.1. Gamma levels at 1 m above the ground surface ranged from 12 to 180  $\mu\text{R/h}$  and averaged 58  $\mu\text{R/h}$ . Gamma levels at the ground surface ranged from 10 to 66  $\mu\text{R/h}$  and averaged 29  $\mu\text{R/h}$ . Highest measurements were recorded in the vicinity of Basins 7905 and 7906 where emanating radiation increased both the 1-m and the surface gamma levels. One-meter gamma levels around Basins 7905 and 7906 were up to 18 times average 1-m gamma levels ( $10 \mu\text{R/h}$ )<sup>11</sup> in uncontaminated areas on the Oak Ridge Reservation.

### 4.2 SURFACE GAMMA SCAN

Results of the surface gamma scan at the HFIR/TRU basins are shown in Fig. 4.2. Typical surface gamma exposure rates over the site generally ranged from 24 to 48  $\mu\text{R/h}$ . Inside the HFIR complex fence, most elevated gamma levels were attributed to radiation emanating from Basins 7905 and 7906. Along the road entering the site from the north, radiation levels increased from 24  $\mu\text{R/h}$  north of the storage tanks to 140  $\mu\text{R/h}$  at the Contamination Area fence surrounding Basin 7906. In addition to radiation from Basins 7905 and 7906, nine specific spots of contamination were identified inside the HFIR complex fence:

- (1) A spot measuring 960  $\mu\text{R/h}$  was found at the northwest corner of a storage shed north of Basin 7905.
- (2) A spot measuring 660  $\mu\text{R/h}$  was located approximately 3 ft east and 8 ft north of the southeast corner of the wall surrounding the Melton Valley process waste storage tanks.
- (3) Gamma exposure rates inside a concrete pit located south of the Melton Valley process waste storage tanks measured 560  $\mu\text{R/h}$ . Although the exact source of elevated gamma radiation was not identified, no gamma contamination was observed around the pump or the concrete.
- (4) A hot spot measuring 380  $\mu\text{R/h}$  was identified on the ground surface directly adjacent to the southeast side of a manhole located south of the storage tanks.
- (5) A spot measuring 270  $\mu\text{R/h}$  was found east of Building 7916.
- (6,7) Spots measuring 240  $\mu\text{R/h}$  were identified east of Building 7904 and south of Basin 7905.
- (8) A spot measuring 120  $\mu\text{R/h}$  was located east of Building 7904.
- (9) A small spot with surface gamma exposure rates of 60  $\mu\text{R/h}$  was identified near the north edge of the gravel parking lot beside Building 7952. During the course of the survey, an underground pipe in this area was replaced. Radiation hazard signs were erected during the soil excavation and pipe replacement.

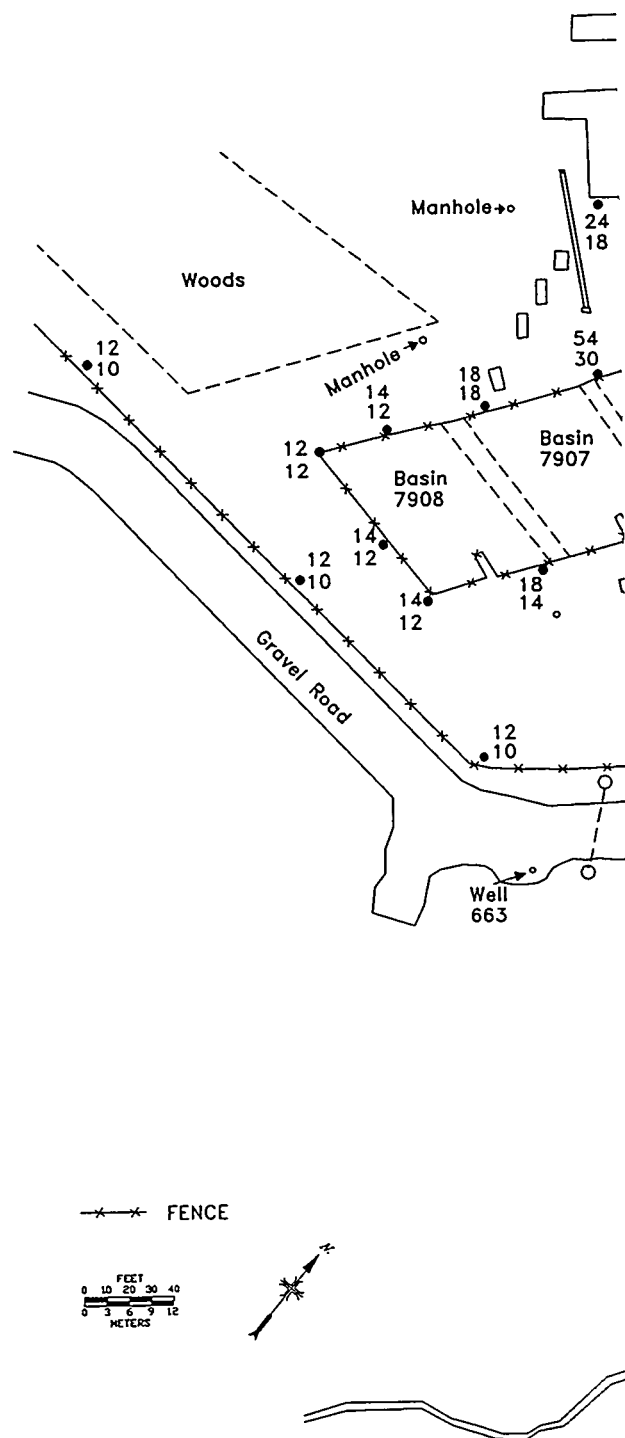
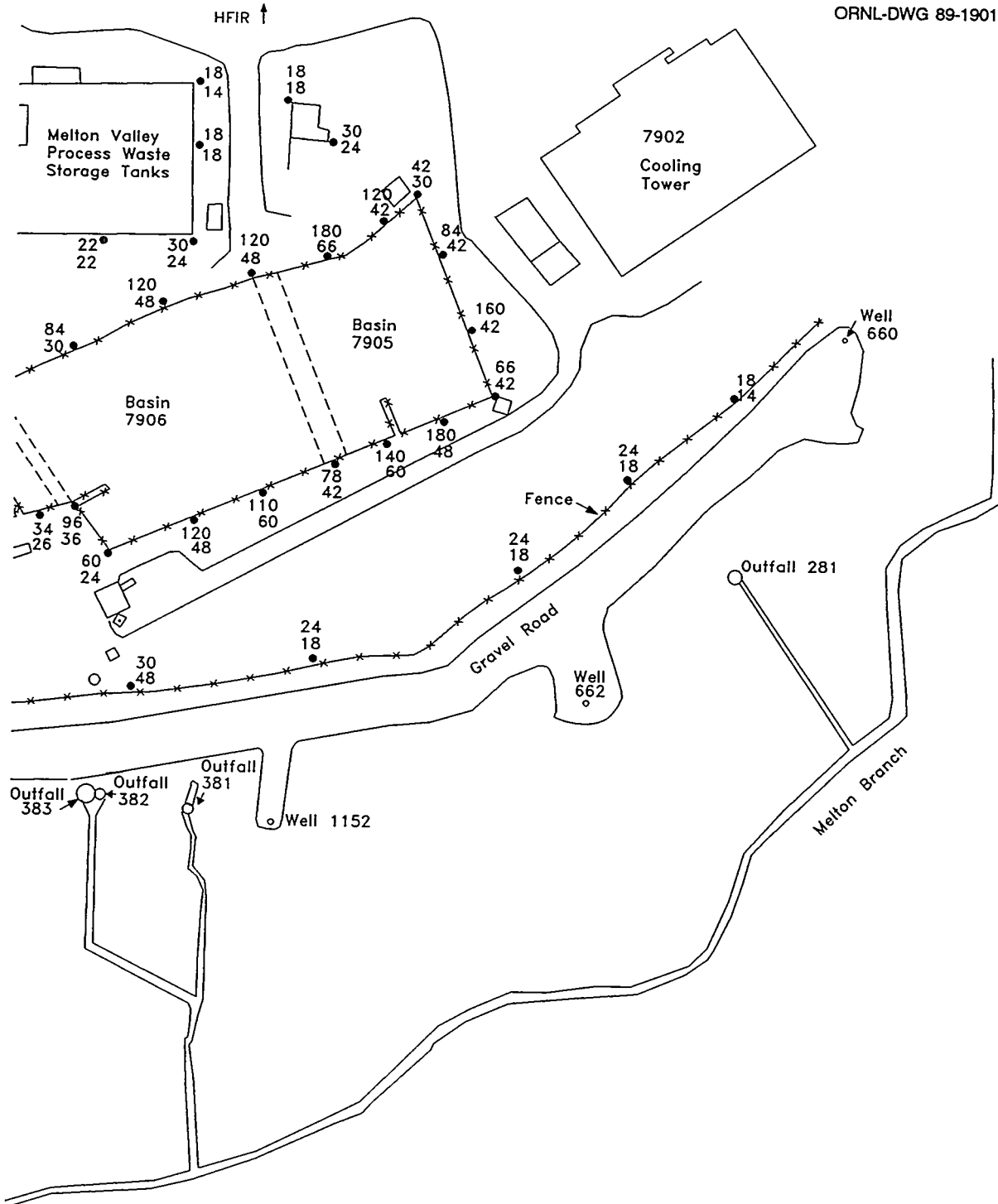


Fig. 4.1. Diagram showing results of gas collection basins. The top number at each point is at the surface.



gamma exposure rate measurements ( $\mu\text{R/h}$ ) at 39 selected points at the HFIR/TRU waste site. The top number is the exposure rate at 1 m above the ground surface; the bottom number is the exposure rate at the ground surface.

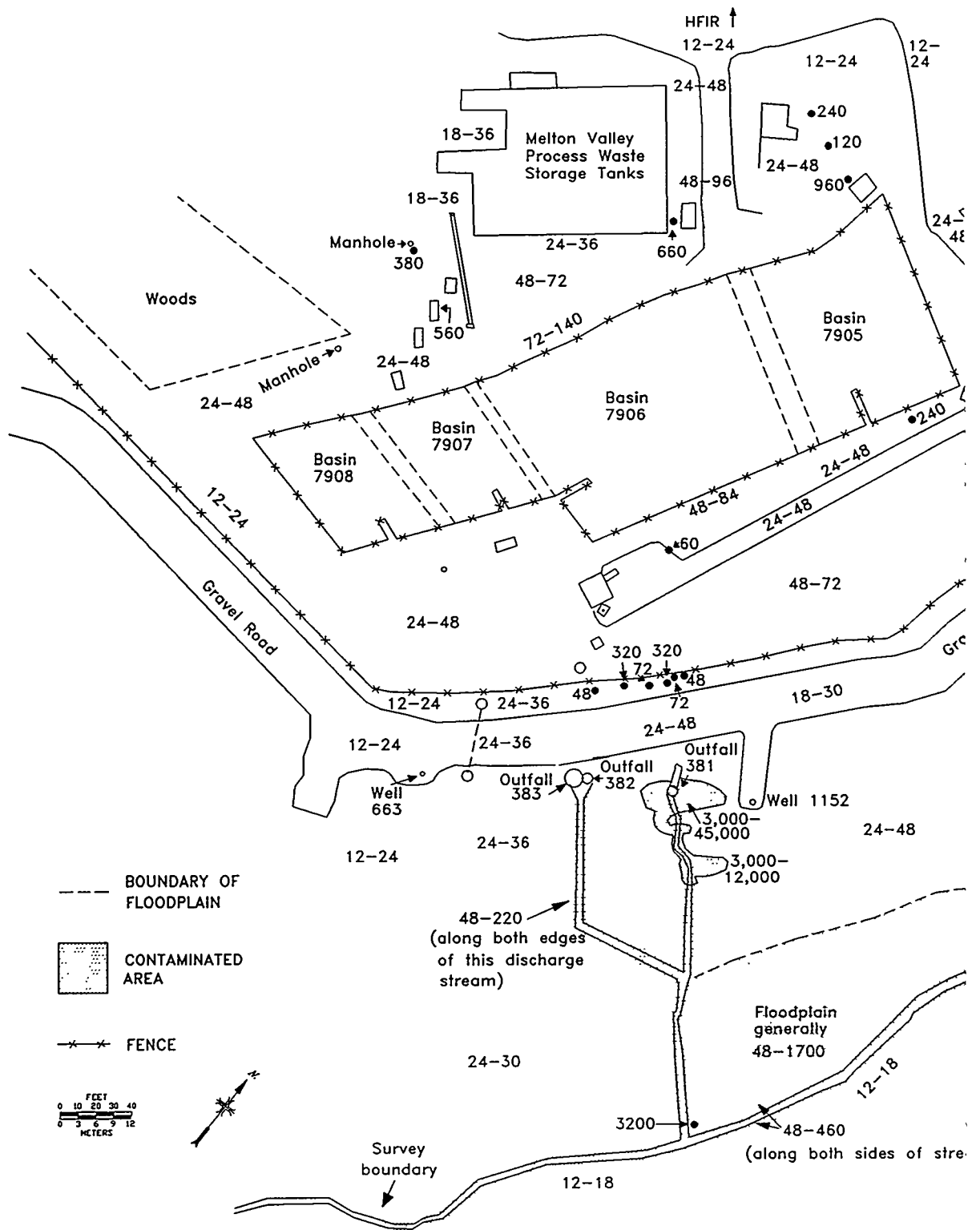
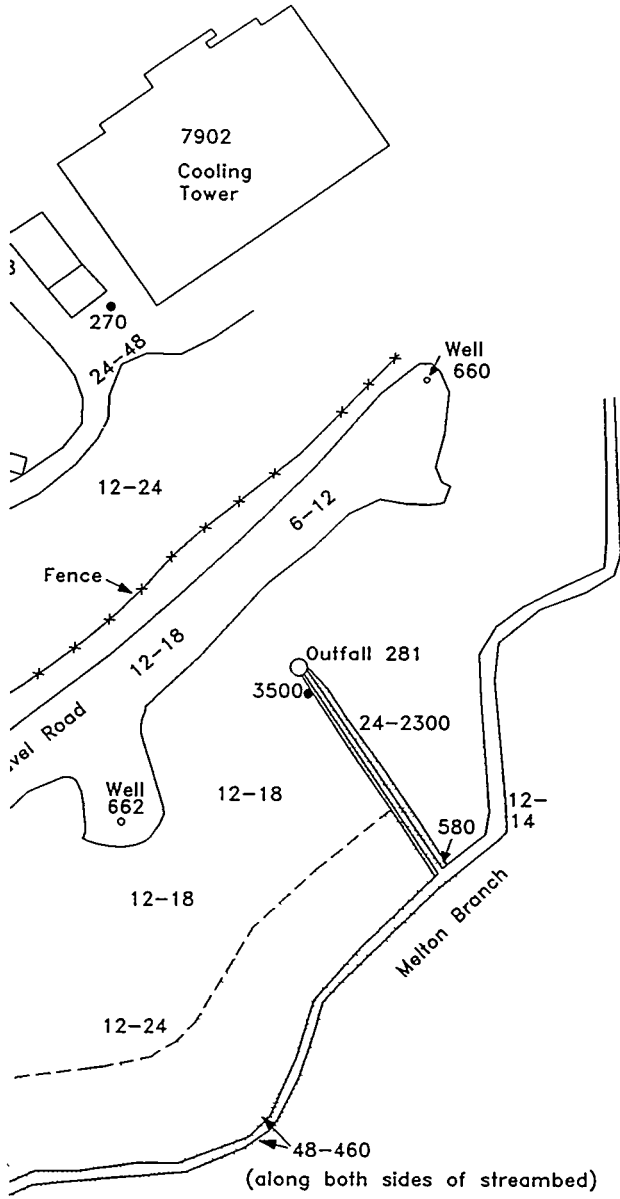


Fig. 4.2. Diagram showing results of surface gamma exposure rate measurements ( $\mu$ ) Basins 7905, 7906, 7907, and 7908.



ambed)

R/h) taken at HFIR/TRU Waste Collection

operation and then removed when the area was covered with gravel and returned to its original condition. Only one small 60- $\mu\text{R/h}$  spot remained after the excavation was completed. Subsurface soil in this area is potentially more highly contaminated.

South of the HFIR complex fence, a series of six small hot spots ranging from 48 to 320  $\mu\text{R/h}$  were identified along the fence line north of the gravel road. South of the gravel road, the most highly contaminated area on the survey site was identified in the area receiving drainage from Outfall 381 (Fig. 4.3). A 5- x 9-m (15- x 30-ft) area showed surface gamma exposure rates ranging from 3000 to 45,000  $\mu\text{R/h}$  measured with the GMSM (3000 to 30,000  $\mu\text{R/h}$  measured with a cutie pie ionization chamber). The hottest spot was less than 1 m<sup>2</sup> and measured 30,000  $\mu\text{R/h}$  at the surface and 9000  $\mu\text{R/h}$  at 1 m above the surface with the cutie pie. The contaminated area was located on either side of the discharge stream from Outfall 381 and was contiguous with a 3- x 9-m (10- x 30-ft) area similarly located further south. The two areas were connected along the stream. Surface gamma exposure rates in the second area ranged from 3000 to 12,000  $\mu\text{R/h}$ .

The ground surface along the edge of the discharge stream from Outfalls 382 and 383 ranged from 48 to 220  $\mu\text{R/h}$ . These measurements were made on the exposed stream bottom, 15 to 60 cm (6 to 24 in.) from the water's edge but within the boundaries of the vertical stream banks cut by the water. The two outfalls discharge into a single stream that merges with the discharge stream from Outfall 381. The merged stream flows south to enter a marshy floodplain (Fig. 4.4). Elevated surface gamma levels of 48 to 1700  $\mu\text{R/h}$  were observed during a scan of the marshy area, which is located outside the WAG 8 boundary. A hot spot measuring 3200  $\mu\text{R/h}$  was found at the confluence of these outfall streams and Melton Branch.

A spot measuring 3500  $\mu\text{R/h}$  was identified at the northwestern edge of the stream from Outfall 281; gamma levels ranged from 24 to 2300  $\mu\text{R/h}$  along the 281 outfall stream as it flowed southeastward to Melton Branch. Elevated gamma levels ranging from 48 to 460  $\mu\text{R/h}$  were observed along both edges of the Melton Branch streambed from the confluence of Outfall stream 281 westward to the survey boundary. The contamination did not appear to extend eastward or southeastward beyond Melton Branch.

### 4.3 SOIL SAMPLE ANALYSES

The locations of soil sample holes are shown in Fig. 4.5 (B and S), and the results of radionuclide analyses (dry wt) are given in Table 4.1. At some locations, samples were collected at more than one depth with A (surface), B, and C designating progressively deeper samples.

Soil sample B1, collected at an elevated spot (180 to 320  $\mu\text{R/h}$ ) underneath an open drain pipe (Fig. 4.6) just south of the HFIR complex fence, contained up to 190 pCi/g <sup>60</sup>Co with concentrations increasing with depth. Sample B2, collected near the highly elevated spot along Outfall 381 discharge, contained up to 42,000 pCi/g <sup>60</sup>Co, 23,000 pCi/g

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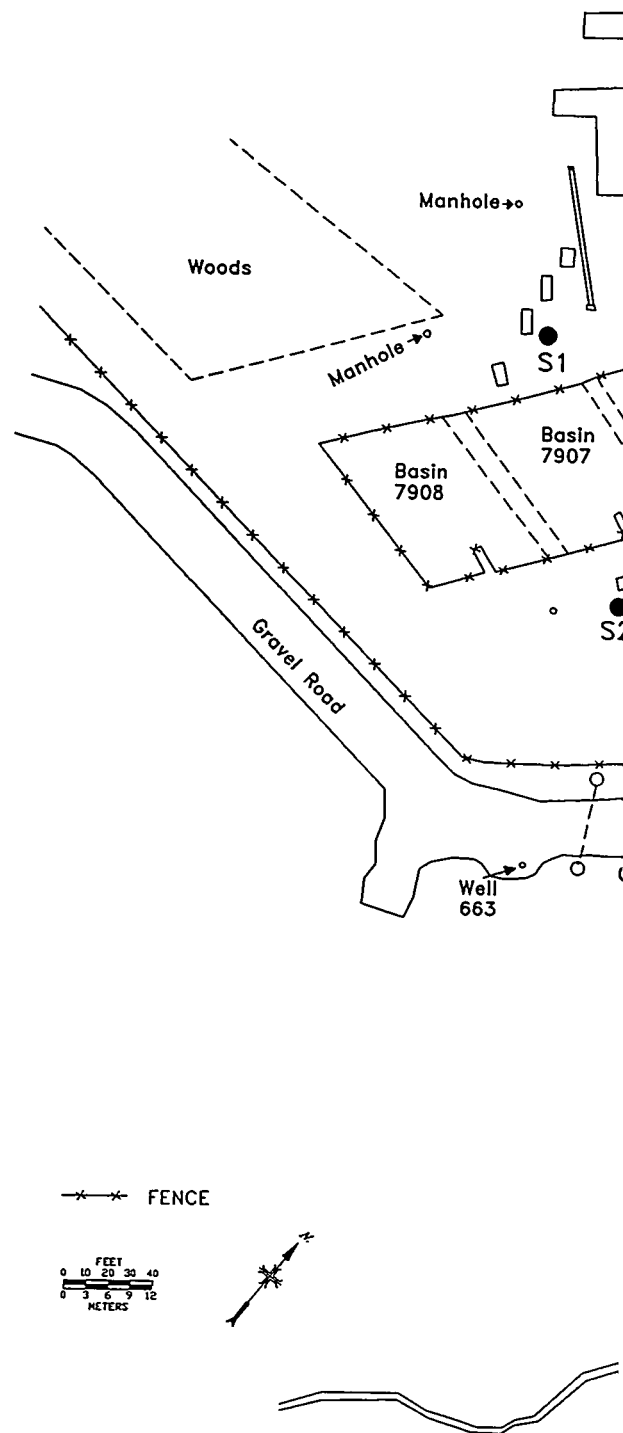


Fig. 4.3. View of Outfall 381 and area of elevated gamma levels.

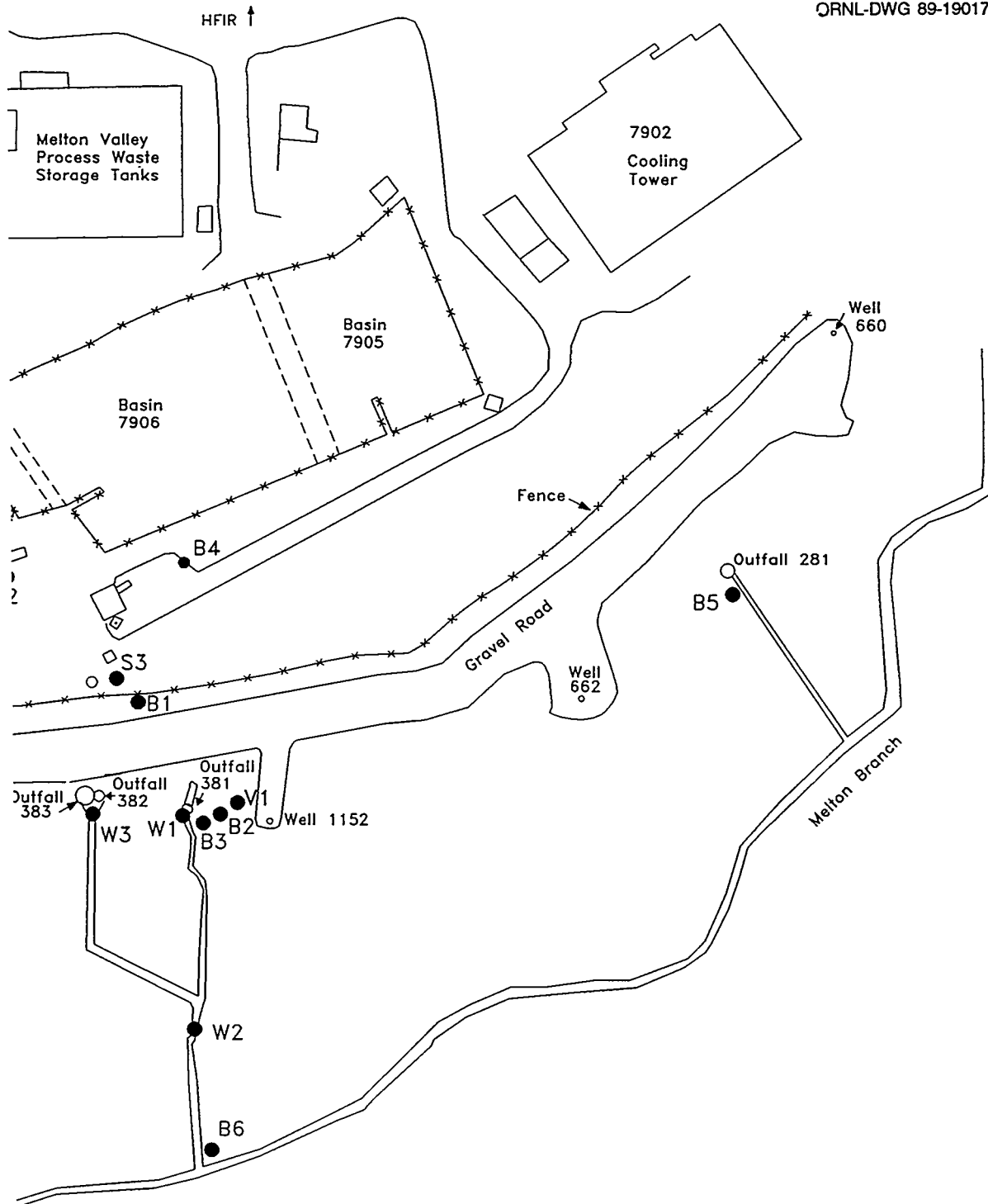
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Fig. 4.4. View of outfall stream as it flows south through the floodplain.



**Fig. 4.5. Diagram showing locations o collection basins.**



f soil (B,S), water (W), and vegetation (V) samples collected near the HFIR/TRU waste

Table 4.1. Concentrations of  $^{60}\text{Co}$ ,  $^{137}\text{Cs}$ , gross alpha, and gross beta in soil samples collected near HFIR/TRU Waste Collection Basins 7905, 7906, 7907, and 7908

Sample ID <sup>a</sup>	Depth (cm)	Activity/concentration in pCi/g (dry wt) <sup>b</sup>				Gamma exposure rates <sup>c</sup> (μR/h)	Location
		<sup>60</sup> Co	<sup>137</sup> Cs	Gross alpha	Gross beta		
Biased samples <sup>d</sup>							
B1A	0-5	110 ± 20	10 ± 5	-16 ± 80	450 ± 3,000	220	Elevated spot by HFIR complex fence
B1B	5-15	140 ± 10	<24	16 ± 80	2,600 ± 3,000	180	
B1C	15-25	190 ± 20	<27	-8.1 ± 70	1,900 ± 2,000	320	
B2A	0-5	42,000 ± 300	280 ± 80	150 ± 100	23,000 ± 3,000	39,000	Near most highly elevated spot at the survey site (45,000 μR/h)
B2B	5-15	23,000 ± 200	230 ± 70	220 ± 100	15,000 ± 3,000	35,000	
B2C	15-30	17,000 ± 80	190 ± 20	-14 ± 60	6,300 ± 2,000	35,000	
B3A	0-5	2,600 ± 30	<19	2.7 ± 60	1,900 ± 2,000	4,900	1.5 m west of sample B2
B4A	0-15	310 ± 8	<5.4	-5.4 ± 50	1,200 ± 2,000	60	Near edge of gravel parking lot
B5A	0-5	4,200 ± 200	260 ± 60	160 ± 600	6,700 ± 13,000	3,500	West side of Outfall 281
B5B	5-15	110 ± 40	330 ± 30	<27	690 ± 7,000	<sup>e</sup>	
B6A	0-5	3,800 ± 100	380 ± 60	110 ± 400	7,500 ± 10,000	3,200	Near confluence of Melton Branch and runoff from Outfalls 381, 382, and 383
B6B	5-15	1,700 ± 100	38 ± 30	<27	94 ± 10,000	3,500	

Table 4.1 (continued)

Sample ID <sup>a</sup>	Depth (cm)	Activity/concentration in pCi/g (dry wt) <sup>b</sup>				Gamma exposure rates <sup>c</sup> ( $\mu$ R/h)	Location
		<sup>60</sup> Co	<sup>137</sup> Cs	Gross alpha	Gross beta		
Systematic samples <sup>d</sup>							
S1A	0-15	0.30 $\pm$ 0.05	0.10 $\pm$ 0.05	12 $\pm$ 10	57 $\pm$ 3	26	North of Basin 7907
S2A	0-15	1.1 $\pm$ 0.05	0.12 $\pm$ 0.06	16 $\pm$ 10	43 $\pm$ 3	24	South of HFIR/TRU basins, inside fence
S3A	0-15	1.1 $\pm$ 1	0.057 $\pm$ 0.03	23 $\pm$ 20	54 $\pm$ 30	26	South of HFIR/TRU basins, inside fence

<sup>a</sup>Sample locations are shown on Fig. 4.5.<sup>b</sup>Counting errors close to or greater than the concentration indicate that the radionuclide is probably not present.<sup>c</sup>Gamma exposure rates measured at upper level of sample depth.<sup>d</sup>Biased samples are collected in areas with elevated gamma exposure rates.<sup>e</sup>Impossible to measure because hole filled with water.<sup>f</sup>Systematic samples are collected in areas with background gamma exposure rates.



Fig. 4.6. Soil sample location B1, a contaminated spot beneath an open drain pipe located immediately south of the HFIR complex fence.

gross beta activity, and 280 pCi/g  $^{137}\text{Cs}$ . Surface gamma exposure rates in this region reached 30,000 to 45,000  $\mu\text{R/h}$ , with gamma levels in the soil sample hole ranging from 29,000  $\mu\text{R/h}$  at 30 cm to 39,000  $\mu\text{R/h}$  at the surface. Sample B3, collected 1.5 m (5 ft) west of sample B2, also contained  $^{60}\text{Co}$ . Sample B4, collected from a small surface spot (60  $\mu\text{R/h}$ ) remaining after a soil excavation and pipe replacement operation, contained 310 pCi/g  $^{60}\text{Co}$ . Sample B5, collected near Outfall 281, contained 4200 pCi/g  $^{60}\text{Co}$  and 330 pCi/g  $^{137}\text{Cs}$ . Sample B6, collected near the confluence of Melton Branch and runoff from Outfalls 381, 382, and 383, contained 3800 pCi/g  $^{60}\text{Co}$  and 380 pCi/g  $^{137}\text{Cs}$ .

Two of the three systematic samples (S1 and S2) collected where gamma exposure rates were at background levels for this site contained detectable levels of  $^{60}\text{Co}$  and gross beta activity.

#### 4.4 WATER SAMPLE ANALYSES

Water sample locations are shown on Fig. 4.5 (W), and results of water sample analyses are presented in Table 4.2. Sample W1, collected south of the HFIR complex fence at Outfall 381, contained 0.3 pCi/mL gross beta activity and 0.06 pCi/mL  $^{60}\text{Co}$ . Concentrations of beta emitters and  $^{60}\text{Co}$  in this sample exceeded those in uncontaminated groundwater by a factor of 2.<sup>12</sup> Gamma exposure rates inside Outfall 381 reached 2600  $\mu\text{R/h}$ . Water sample W3, collected at Outfalls 382 and 383 contained 0.49 pCi/mL  $^{60}\text{Co}$ , exceeding levels in uncontaminated groundwater but well below the Derived Concentration Guide (DCG) values for ingested water.<sup>13</sup> A third water sample (W2), collected south of the outfalls just before the drainage stream entered the floodplain, was not contaminated.

#### 4.5 VEGETATION SAMPLE ANALYSES

Location of the single vegetation sample is shown on Fig. 4.5 (V1). This sample, collected south of the HFIR complex fence near the most highly contaminated spot on this survey site (30,000 to 45,000  $\mu\text{R/h}$ ), contained  $59 \pm 3$  pCi/g gross beta activity,  $32 \pm 3$  pCi/g  $^{60}\text{Co}$ ,  $1.5 \pm 0.6$  pCi/g gross alpha activity, and  $0.26 \pm 0.08$  pCi/g  $^{137}\text{Cs}$ . These results indicate the presence of beta activity and  $^{60}\text{Co}$  in this sample.

Table 4.2. Concentrations of  $^{60}\text{Co}$ ,  $^{137}\text{Cs}$ , gross alpha, and gross beta in water samples collected south of HFIR/TRU Waste Collection Basins 7905, 7906, 7907, and 7908

Sample ID <sup>a</sup>	Activity/concentration in pCi/mL				Comment
	$^{60}\text{Co}^{b,c}$	$^{137}\text{Cs}^{b,c}$	Gross alpha <sup>d,e</sup>	Gross beta <sup>d,f</sup>	
W1	0.062 ± 0.03	<0.024	0.00054 ± 0.001	0.30 ± 0.03	Sample of drainage from Outfall 381. Gamma levels measured 2600 $\mu\text{R/h}$ inside outfall
W2	<0.027	<0.027	0.0017 ± 0.002	0.014 ± 0.005	Collected south of outfalls before stream enters floodplain
W3	0.49 ± 0.05	<0.022	0.00016 ± 0.0009	0.0024 ± 0.003	Sample of drainage from outfalls 382 and 383

<sup>a</sup>Sample locations are shown on Fig. 4.5.

<sup>b</sup>Cobalt-60 and  $^{137}\text{Cs}$  analyses were performed in accordance with Environmental Protection Agency (EPA) Procedure 901.1.

<sup>c</sup>Uncontaminated groundwater in the Oak Ridge area usually contains <0.014 pCi/mL  $^{60}\text{Co}$  and  $^{137}\text{Cs}$  (ref. 12).

<sup>d</sup>Gross alpha and gross beta analyses were performed in accordance with EPA Procedure 900.0.

<sup>e</sup>Uncontaminated groundwater in the Oak Ridge area usually contains <0.054 pCi/mL gross alpha (ref. 12).

<sup>f</sup>Uncontaminated groundwater in the Oak Ridge area usually contains <0.14 pCi/mL gross beta (ref. 12).

## 5. SIGNIFICANCE OF FINDINGS

Gamma exposure rates on the Oak Ridge Reservation in uncontaminated locations typically average 13  $\mu\text{R/h}$  and range from 10 to 17  $\mu\text{R/h}$  at the ground surface. Ground-surface gamma exposure rate measurements taken outdoors at the HFIR/TRU waste collection basins and surrounding area were generally above background. Typical surface gamma levels ranged from 24 to 48  $\mu\text{R/h}$  over the survey site. These elevated levels are due to radiation emanating from Waste Collection Basins 7905 and 7906 and residual radionuclides in contaminated soil.

Contamination found within the HFIR complex fence was confined to nine small isolated spots ranging from 60 to 960  $\mu\text{R/h}$ . Most of these spots could only be identified when the scintillator was directly over the point source. South of the HFIR complex fence, contaminated areas of surface soil were widespread but localized along Melton Branch, Melton Branch floodplain, and waste streams from Outfalls 281, 381, 382, and 383. This pattern suggests that the contamination now located south of the HFIR complex originated from operations within the HFIR facilities.

To date, the most significant and immediate radiological concern is a contaminated soil area that receives drainage via Outfall 381. Figure 4.2 depicts this area of surface contamination with levels of gamma exposure rates at specified locations. The maximum surface gamma exposure rate measured in this area was 45,000  $\mu\text{R/h}$ . Analyses of soil, vegetation, and water samples collected from this area show  $^{60}\text{Co}$  and gross beta emitters as the major radiological contaminants. In surface soil sample B2A,  $^{60}\text{Co}$  and gross beta activity levels were 42,000 and 23,000 pCi/g, respectively, suggesting that contaminant levels are higher at Outfall 381 than in the sediment of Basin 7906 (see Table 2.1). This could possibly be due to (1) accumulation of residual contamination at Outfall 381 over a period of discharge time or (2) additional sources of contamination contributing to overall concentrations of  $^{60}\text{Co}$  and gross beta activity. Radiation measurements indicate that residual contamination extends from the outfall areas southward and into Melton Branch.

Although only one vegetation sample was collected and analyzed, the presence of radionuclides (59 pCi/g gross beta activity; 32 pCi/g  $^{60}\text{Co}$ ; 1.5 pCi/g gross alpha activity) may represent a potential human health risk for unprotected personnel involved with activities that may disturb surface vegetation (e.g., grass mowing) and/or surface soil. In addition, soil samples should be taken along the gravel/dirt road for radiological screening.

## 6. RECOMMENDATIONS FOR CORRECTIVE ACTIONS

Because of the radiation shielding properties of water, external radiation levels may change as a result of water level fluctuation in the contaminated Waste Collection Basins 7905 and 7906. Therefore, radiological data presented in this draft report should be considered as a "snapshot" assessment applicable only for the dates of the surveys. The proposed corrective action options are based on the results of this survey and should be considered as interim evaluations pending further detailed radiological and hazardous waste characterizations of the basins and environs.

Elevated levels of ground-surface gamma radiation and concentrations of radionuclides in soil and vegetation warrant the need for corrective action measures. The primary basis for implementing these measures is the minimization of exposures of personnel to radiation. These recommendations are in accordance with the radiation safety policy of ORNL to conduct all operations in such a manner that personnel exposures to radiation or contamination are maintained at a level as low as reasonably achievable (ALARA).

Two basic approaches to interim corrective actions are (1) isolation of contaminated areas (e.g., fencing), including measures to prevent further dispersion of radioactivity, and (2) removal, treatment (if needed), and disposal of contaminated soil, ground cover, and vegetation and subsequent stabilization of the treated areas. Health risk assessments should be conducted and used in the evaluation of remedial action options. Because high concentrations of radiotoxic nuclides (e.g.,  $^{60}\text{Co}$ ) were identified in contaminated soil areas, the removal, treatment, and disposal of soil may pose a greater health risk than leaving it in situ. A "leave-in-place" option, coupled with the application of proven, demonstrable technologies for long-term stabilization and/or reduction of radiation exposures, should be considered for highly contaminated areas.

Corrective action options listed below include ground-surface measures to limit human exposures, minimize surficial dispersion of contamination, and monitor any such dispersion. Not every contamination situation would involve the implementation of all recommendations listed below; rather, the recommendations should be considered individually or in appropriate combinations. A more detailed investigation (with core hole borings and soil analysis) would be required to fully characterize the radiological status of the waste basins and environs and to address the most appropriate methods and technologies for effective, long-term remediation.

### *Isolation of contaminated areas*

- Gamma exposure rate measurements at the boundary of the contaminated soil region revealed 3000  $\mu\text{R/h}$  at 1 m from the ground surface (the highest surface reading was 45,000  $\mu\text{R/h}$ ). Based on guidelines for establishing radiation control zones stated in the ORNL Health Physics Procedure Manual, it is recommended that Radiation Area control measures be implemented at this region.<sup>14</sup> These actions include warning signs, definition of zone boundaries, and access control procedures. Radiation control

measures observed during the course of the survey were limited to the HFIR complex fence north of the gravel road. Currently (04/04/90), no control measures are present at the contaminated soil region circumjacent to Outfall 381 (see Fig. 4.2). We recommend that the number of zone portals (point of entrance and exit) be limited to one. A diagram of the outfall area showing surface radiation levels and region of surface contamination should be posted at the zone portal. Because Outfall 381 is a designated NPDES sampling point and is located at this contaminated soil region, we recommend that personnel involved with sampling this outfall contact the Radiation Protection Section of the Environmental and Health Protection Division prior to entering the zone.

- Radiation control measures at the surface hot-spot cluster found near the HFIR complex fence (north of the gravel road, Fig. 4.2) should be considered. Warning signs should be posted with instructions to contact the Radiation Protection Section of the Environmental and Health Protection Division before entering this area. Based on recommendations outlined in the ORNL Health Physics Procedure Manual, "Radiation Hazard—Keep Out" signs would be applicable to this area.<sup>14</sup> This type of warning sign is used primarily "in areas outside the main confines of the Laboratory and where members of the general public should be warned."
- If remedial or cleanup actions are not implemented, active and passive institutional control measures should be maintained for a specified period of time to allow for radioactive decay of intermediate-lived fission waste products such as <sup>90</sup>Sr and <sup>137</sup>Cs. Long-term institutional control (~300 years) would result in a 99% reduction of <sup>90</sup>Sr and <sup>137</sup>Cs activities (~10 half-lives). The half-life of <sup>60</sup>Co is 5.27 years. Periodic monitoring of radioactivity in vegetation, soil, surface water, and groundwater should be performed.
- Radiation protection measures (e.g., personal radiation monitoring devices) should be considered for all personnel who are involved with activities that may disturb surface soil (e.g., well drilling) at the HFIR facilities and environs. Additionally, at radioactively contaminated soil areas, all activities that may potentially disturb and/or disperse radioactivity should cease if personnel involved with these operations (e.g., grass mowing) do not wear some type of radiation protection gear. Personal respirators would minimize the potential for inhalation of radioactively contaminated soil/dust particles.
- Stabilization procedures (e.g., earthen caps, hydrologic isolation, and limited in situ grouting or vitrification) should be considered at radioactively contaminated soil areas where short- or intermediate-lived waste products have been identified.
- External radiation levels could be reduced at contaminated areas by covering contaminated ground-surface areas with clean, uncontaminated soil. However, if eventual remedial action requires removal of contaminated soil, the added cover would increase the volume of waste to be disposed of.

***Removal, treatment, and disposal of contaminated material***

- At the highly contaminated areas, soil, ground cover, and vegetation could be removed, treated (if needed), and disposed of in a designated radioactive waste disposal site. Excavation and removal of the contaminated soil must be carried out in full compliance with guidelines stated in the *Health, Safety, and Environmental Protection Procedures for Excavating Operations* manual.<sup>15</sup> It is essential that ORNL health physics personnel be present to monitor all activities associated with any disturbance of soil at the HFIR facilities and environs.
- Land stabilization procedures (e.g., earthen caps, hydrologic isolation, limited in situ grouting or vitrification) should be considered for the remediated areas.

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